Chemistry I Kinetic: Molecular Theory Notes

Introduction:____

____

Kinetic Molecular Theory has three points:

- 1. ____

  ____

- 2. ____

  ____

- 3. ____

  ____

Basic information needed to work with the KMT of matter:

1. Forces between molecules

- Attractive forces exist between ALL molecules.
  - These are called ____
    - two classifications:

  – A.____

  ____

  – B.____

  ____

2. Molecules and dipoles

- Most covalent compounds ____
- A dipole is a molecule even though there is a sharing of e^{-1}s (covalency), __________

  ____

  ____

    - like HCl

$$\underset{\delta+}{H} \longrightarrow \underset{\delta-}{Cl}$$

KMT Notes: solids

Basic Information	Characteristics	Explained by KMT

Solids as crystals

- Crystalline
  - Crystals are ____
    ____
    - Ex: ____
  - Amorphous solid has a ____
    - Ex: ____
  - Note: the 7 different types of geometric patterns have been defined by x-ray diffraction techniques

Crystals and binding forces

- If molecules are nonpolar, then the____
- If the molecules are polar, then the ____

through ____

____

4 general categories of crystals

- 1. Ionic crystal
- 2. Covalent network
- 3. Metallic crystal
- 4. Covalent molecular crystal

Crystals

Type data	Ionic	Covalent Network	Metallic	Covalent molecular
Made of				
Binding forces				
Melting points				
Heat and electricity conductors				
Physical properties				
Examples:				

Solids and change of state

- Solids can change from ____

  ____
- Some solids can jump from a ____
- The term given to this is____.
- .__________________________is involved in this process.
- Definition: molar heat of fusion: ____

  ____

  Note: a solid can go from solid to liquid to gas and a dynamic equilibrium can be reached with melting and freezing
- Solids like CO_2 & I_2 and naphthalene go directly from solid vapor.
- This is called______________________. They have high equilibrium vapor pressure.
- To change a solids state:

.____

____

____

– For pure solids, the m.p. and f.p. are______________________________________

Liquids

Basic Information	Characteristics	Explained by KMT

Evaporation

1. Evaporation happens when ____

   ____

   ____

   ____

   ____

   ____

2. Vapor is the gas of a material ____

   ____

   ____

   ____

   ____

3. These vapor molecules also exert a pressure_________________________________

   ____

   ____

   ____

   ____

   ____

Physical Properties of Liquids

1. Boiling

– Defined: the boiling point of a liquid is the temperature ________________________

____

____

____

2. Applied pressure:
   - Pascal's Law : the pressure on a liquid in a confined container _______________

____

____

What happens when liquids boil

- 1. When boiling begins:
  - Vapor bubbles rise ____ __________________

  (where it's hottest).

  - If the vapor pressure on the liquids surface is not yet equal to atmospheric pressure____

    ____

- 2. As temperature of the liquid increases vapor pressure increases a temperature is reached where ____

  ____

  ____

- 3. Vapor bubbles rise to the surface, evaporation occurs readily BUT _______________

  ____

  ____

- It is at its boiling point (b.p.).
-
- Boiling points listed in literature are adjusted to standard pressure.

Does atmospheric pressure affect b.p.?

- 1. High pressure will produce a higher b.p. Why because:

  A.____

  ____

  B.____

  ____

- 2. Low pressure will lower the b.p. because

  A.____

  ____

  B.____

  ____

Test quest: How would the boiling points of the same compound such as water differ between Denver, Co. and Death Valley Ca.?

- Once boiling occurs, ____

  ____

  ____

  ____

  ____

- Note: temperature of vapor at boiling______________________________

  ____

- Heat must be supplied continually.

- Extra energy is needed to ______________________________between liquid molecules so the molecules will go further apart like gasses

Standard Heat of Vaporization

- Definition: ____

  ____

  ____

  ____

  ____

  ____

- What does it depend on?______________________________________

  ____

  ____

Basic Information	4 Characteristics	Explained by KMT

Liquefying gases

- Converting a material that is normally a gas at r.t. to become a liquid.

- Applying the combined gas law with both volumes constant ______________________

  ____

- Why ?____

  ____

  ____

  ____

- The Process looks like this.
- So, we
  - 1. Compress gas molecules
  - 2. They come closer together
  - 3. Extra heat energy is removed by a coolant
  - 4. The gas molecules are allowed, at its starting temperature, to re-expand to original volume. *in re-expanding, the gas loses energy. So, it is at the same volume but at lower temperature.
- The procedure is repeated:
  - 1. Compression is again applied
  - 2. Extra absorbed energy is removed
  - 3. In re-expanding, the gas loses more energy(cooler).
- What's happening?
  - The lowered temperature slows molecular movement. The increased pressure crowds molecules together. Eventually, attractive forces cause the gases to condense onto liquid form.

Dynamic Equilibrium

- Generally speaking this means ____

  ____

  ____

- Take the case of evaporation: ____

  ____

  ____

- Eventually, the number of vapor molecules condensing will equal the liquid molecules evaporating.
    - There is no net change; there is an equilibrium.

- However, the evaporation and condensation don't stop! It is the rates that are equal. The rates are at equilibrium.

- It is called a dynamic condition because ______________________________________

  ____

- They can be shown in equation form:

  – Evaporation: $liquid + energy \rightarrow vapor$

  – Condensation: $vapor - energy \rightarrow liquid$

  or $vapor \rightarrow liquid + energy$

Dynamic Equilibrium

- Finally combining the last two equations:

  $vapor \leftrightarrow liquid + energy$

Equilibrium vapor pressure

- When this condition exists,____
- This creates an ____
- This pressure is particular to the liquid and is temperature dependent.
- By definition: equilibrium vapor pressure is the pressure exerted by a vapor in equilibrium with its liquid.

Disturbance in the equilibrium

- What will happen if the temperature of a liquid is increased?
    - .____
    - .____
    - .____
- This will upset the equilibrium.

- If a higher temperature is maintained then ______________________________________
____
____

Disturbance in the equilibrium

- Equilibrium vapor pressure depends on:
  - Temperature
  - Attractive forces between liquid molecules
  - Note: if forces are strong; molecules will keep together causing the vapor pressure to be lower.

So what happens when……

- If:
  - A. increase (or decrease) temperature, the vapor-liquid equilibrium is upset.
  - B. an upset causes a stress on the system
  - C. a stress to one rate (forward or backward) upsets the equilibrium(knocks it out of whack)
  - D. it is possible to shift the equilibrium in a desired direction.

Le Châtelier's Principle

- Was formulated in 1888 and says:
  - If a system at equilibrium is subjected to a stress(upset), ______________________
    ____
    ____
  - This applies to ALL types of____

Le Châtelier's Principle and liquid-vapor systems

- 1. if temperature is raised: more energy; molecules moving faster, more molecules into vapor state; higher vapor pressure: new equilibrium established
- 2. If temperature is lowered: less energy; molecules moving slower; fewer molecules in vapor state; new equilibrium with lower vapor pressure.

Critical Temperature and Pressure

- Gases have a certain temperature and a certain pressure at which they will liquefy.
- Definition: critical temperature: the highest temperature at which it is possible to liquefy a gas with any amount of pressure
- Definition: critical pressure: the pressure required to liquefy a gas at its critical temperature.

- Definition: critical volume: the volume occupied by 1 mole of a gas at its critical temperature and critical pressure.
- Let's say it this way: critical temperature is the temperature above which a gas cannot be liquefied no matter how much pressure is applied.

Critical temperature and attractive forces

- There is a relationship between critical temperature and attractive forces.
  - The higher the critical temperature, the greater the attractive forces once the gas has become a liquid.
  - The lower the critical temperature, the weaker the attractive forces.
  - Example: water vapor has a high critical temperature, and water has much attraction in its polar structure.

- Nonpolar covalent molecules like O_2 , N_2 and H_2 do have attractive forces, but they are weak dispersion (van der Waal) forces.
- General Rule: higher critical temperature usually means higher attractive forces in liquid molecules and usually a greater molecular weight.

Water

- Physical properties of dihydrogen monoxide
  - Transparent
  - Odorless
  - Colorless
  - Tasteless
  - f.p. = 0^oC @ standard pressure
  - b.p. = 100^oC @ standard pressure

Special Property of water

- Water does some really weird thing we it cools down. Like most substances, it contracts (particles move closer) as it cools. BUT at 4^oC, water begins to expand (increase in volume and becomes less dense). As it forms ice, it has expanded more and is less dense; that's why ice floats in water. Water reaches its maximum density at 3.98^oC (1.0000 g/mL)

Water molecule

Water molecule showing dipoles & bond angle

Water dipoles and association

- Diagram of polarity and hydrogen bonding in water molecules.

Hydrogen bonding

- Hydrogen bonding is weak chemical bonding between a hydrogen atom in one polar molecule and a very electronegative atom in a second polar molecule.

- Hydrogen bonding in water accounts for:
  - 1. Water being a liquid at r.t.
  - 2. The hexagonal crystal structure of ice (water molecules in hexagonal rings together)

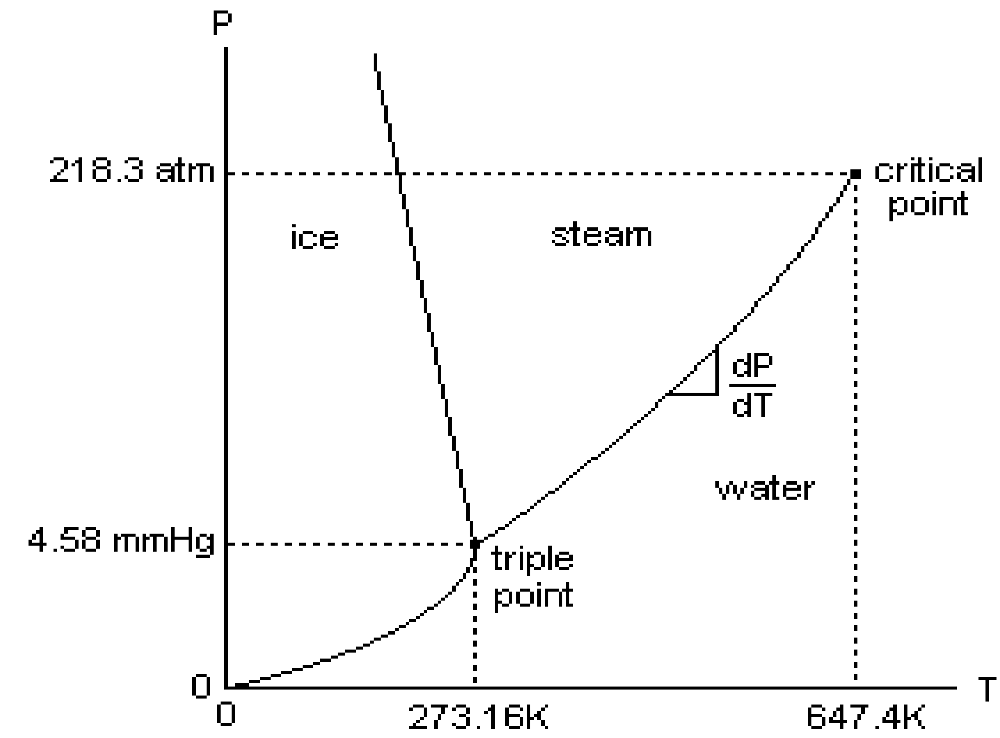
- Hydrogen bonding is confined to hydrogen and small electronegative atoms such as oxygen, fluorine, and nitrogen.(this is why NH_3 has a high critical temperature and is used as a refrigerant.)

Ice

- Melting ice: when heated, hydrogen bonds stretch because they are flexible. Groups of molecules in liquid form are more compact than groups of molecules in solid form (ice) where they are in fixed positions. (same # of molecules of ice have more volume than same # of molecules of liquid water) ice is less dense than cold water so it floats!!!!
- When more heat is applied (absorbed), the hydrogen bonds (not the O-H bonds) break. The water molecules when first forming liquid cluster closer together.
- As they gain enough energy, they break free from the hydrogen bonding to become single molecules.

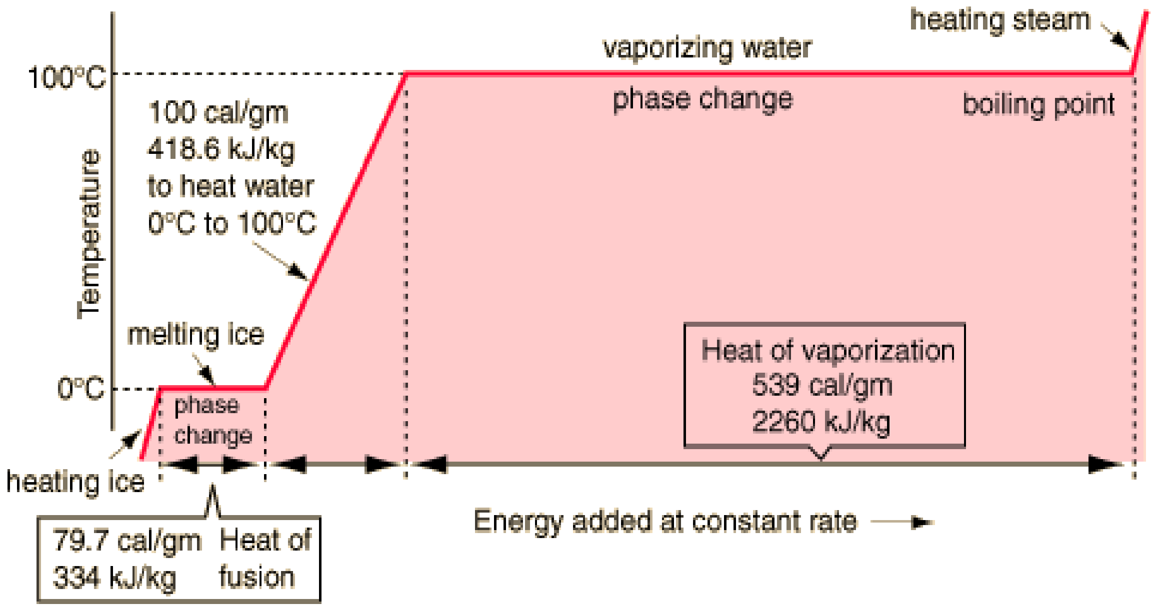
Chemical behavior of water

- Water is quite chemically stable.
- Require electric current for decomposition.



Phase Diagram for Water

This is the phase diagram of water. This shows the phases (solid, liquid & gas) of water according to pressure and temperature. At 4.58 mmHg and close to absolute zero water will be in all three phases at once. This is called **the triple point**.



This is a phase change diagram for water. The x-axis is energy and the Y-axis is temperature. The plateaus are the melting and boiling points.